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Fidelity Correlation Requirements For Distributed Interactive Simulation: Draft Rationale

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INSTITUTE FOR SIMULATION AND TRAINING

SEPTEMBER 1993

DRAFT RATIONALE
FIDELITY CORRELATION
REQUIREMENTS FOR DISTRIBUTED
INTERACTIVE SIMULATION

IST-CR-93-34

IST

Contract Number N61339-91-C-0091
STRICOM
DMSO
September 1993

**Draft Rationale
Fidelity Correlation
Requirements for Distributed
Interactive Simulation**



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Rationale for Fidelity Description Standard

1. Scope This document provides the rationale behind the *DIS Fidelity Description Standard*. The standard defines a collection and organization of information that allow the Owners of DIS-compliant simulators, simulations, and models to describe the "fidelity" of their systems for potential DIS Users. Users interconnect these simulators, simulations, and models to provide real-time, warrior-in-the-loop simulation applications with the level of fidelity appropriate for supporting the specific training, analysis or test objectives of the application. The fidelity information required by the standard is concerned with those characteristics that might influence human perception or behavior during a distributed simulation application, as well as those that determine the compatibility and consistency of simulators, simulations, and models for an intended purpose.

This rationale document explains why particular fidelity characteristics are chosen, and the reasons for the overall organization of the information. The simulations or models that may be used in a particular DIS application were designed for diverse purposes. Fidelity characteristics that are important for one DIS application may not be important for another. Any decision to use a particular simulator, simulation or model in a given application should clearly be a function of the objectives of that application. Another major consideration is the effect of the network on application validity. Thus the standard does not prescribe any minimum level of fidelity for simulators, simulations, and models to participate in DIS applications. The User must make this decision.

To support this decision process, the standard recommends that a *fidelity characteristics repository* be developed which permits a User to readily access the information in order to assess which simulators, simulations, and models are appropriate candidates for a given application. This rationale document discusses how Owners characterize their simulators, simulations, and models, and how Users select the simulators, simulations, and models to employ in any DIS application. Figure 1 illustrates key elements and processes.

2. Rationale for definitions - The DIS community has long recognized that a common vocabulary is an important tool for defining requirements and discussing issues. A *DIS Glossary* has been developed, and the definitions therein should be adhered to and understood by all members of the community.

2.1. Fidelity - Definitions are especially important where fidelity is concerned. Understanding the term "fidelity" is paramount. There is no minimum fidelity level required for a DIS compliant system. The actual required level of fidelity varies from application to application, and is clearly application dependent. Since DIS supports both military and commercial applications, Hayes' (1980) definition of fidelity is appropriate and is proposed here. Fidelity is defined as "the similarity, both physical and functional, between the simulation and that which it simulates."

2.2. Fidelity Characteristic - Fidelity should be defined as quantitatively as possible. This is not an easy task, due to its subjective nature. A set of descriptors, herein termed *fidelity characteristics*, is necessary. These fidelity characteristics make up the elements of the database described by the standard.

2.3 Other Definitions (*use DIS Glossary or standard scientific references*)

3. Taxonomy - There are thousands of simulators, simulations, and models that could be used in a DIS application. Users cannot contact each Owner to determine the appropriateness and availability of that Owner's simulation for use in a DIS application. A taxonomy is key to providing potential Users with ready access so that they can identify a subset of good candidates. Once this subset is identified, individual Owners can then be contacted regarding the cost and availability of their systems. DOD DIS applications will require a formal Verification, Validation, and Accreditation (VV&A) process.

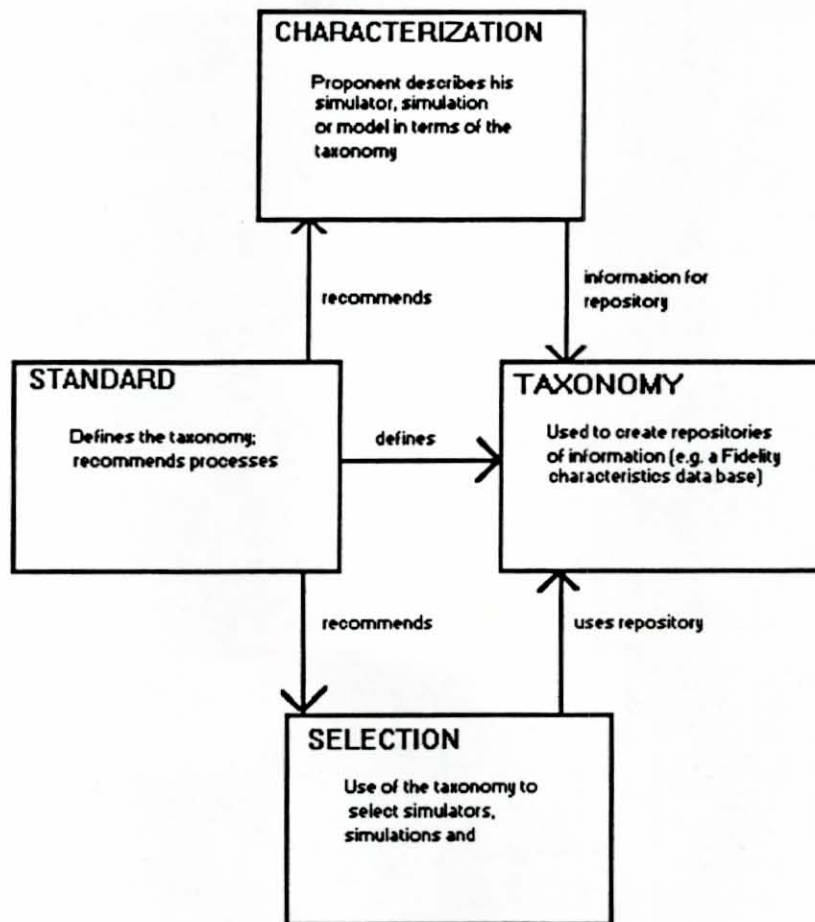


Figure 1 The Standard Concept

The taxonomy is organized as follows:

- a. **DIS Resource:** A combination of hardware and software components that can be connected to and interoperate within a DIS application. *(Provide examples)*
- b. **Fidelity Domain:** A group of related capabilities of a DIS resource that may affect the fidelity of a DIS application. The standard identifies five fidelity domains, the action space entity represents a system, group of systems, group of systems and personnel, etc., that is potentially available for use in a DIS application. The environment represents the external world seen by a DIS resource. The host describes the computer, or larger simulator on which the DIS Resource is hosted. The site describes one or more host connected to the network through a common gateway. The application describes properties of a particular use of DIS.
- c. **Capability:** A property that describes a type of action that a DIS resource can perform or represent. *(Provide examples)*
- d. **Implementation:** The means by which a capability is realized. *(Provide examples)*

e. Characteristic: A distinctive quality of an implementation or characteristic. The definition is recursive at this level to provide flexibility to cover all simulations, simulators, and models. *(Provide examples)*

f. Descriptor: A measurable feature of one or more characteristics, including units and definition of measurement.
(Discuss infrastructure for database, overall organizing philosophy, etc.)

4. Rationale for Database Taxonomy - *(Details to be supplied by others)*

4.1. Action Space Entity

- 4.1.1. Communication
- 4.1.2. Sensors
- 4.1.3. Movement
- 4.1.4. Appearance
- 4.1.5. Weapons
- 4.1.6. Vulnerability/Susceptibility
- 4.1.7. Behaviors/Rules of Engagement
- 4.1.8. C2I
- 4.1.9. Mechanical Countermeasures
- 4.1.10. Logistical/Maintenance Interface
- 4.1.11. Electronic Warfare
- 4.1.12. Combat ID/IFFN
- 4.1.13. Navigation
- 4.1.14. Fire Control/Targeting
- 4.1.15. Reliability/Availability

4.2. Environment

- 4.2.1. Contents (Excluding Action Space Entities)
 - 4.2.1.1. Land
 - 4.2.1.1.1. Surface
 - 4.2.1.1.1.1. Contours
 - 4.2.1.1.1.2. Elevations and Contours
 - 4.2.1.1.1.3. Features
 - 4.2.1.1.1.4. Vegetation
 - 4.2.1.1.1.5. Surface Characteristics
 - 4.2.1.1.1.6. Cartography (Projection)
 - 4.2.1.1.1.7. Man-made Objects
 - 4.2.1.2. Sea
 - 4.2.1.2.1. Sea State
 - 4.2.1.2.2. Currents
 - 4.2.1.2.3. Tides
 - 4.2.1.2.4. Opacity
 - 4.2.1.2.5. Turgidity
 - 4.2.1.2.6. Salinity
 - 4.2.1.2.7. Bioluminescence
 - 4.2.1.2.8. Man-made Objects
 - 4.2.1.2.9. Water Temperature
 - 4.2.1.2.10. Seabed Characteristics
 - 4.2.1.2.11. Seabed Contours and Elevation

- 4.2.1.2.12. Ice Models
- 4.2.1.2.13. Wind
- 4.2.1.3. Atmosphere
 - 4.2.1.3.1. Weather
 - 4.2.1.3.1.1. Precipitation
 - 4.2.1.3.1.2. Haze/Dust/Obscurants
 - 4.2.1.3.1.3. Humidity
 - 4.2.1.3.1.4. Wind
 - 4.2.1.3.1.5. Temperature
 - 4.2.1.3.1.6. Clouds
 - 4.2.1.3.1.7. Barometric Pressure
 - 4.2.1.4. Space
 - 4.2.1.4.1. Sun
 - 4.2.1.4.2. Moon
 - 4.2.1.4.3. Stars
 - 4.2.1.4.4. Non-Entity Satellites
 - 4.2.1.5. Ephemeral
 - 4.2.1.5.1. Time of Day
 - 4.2.1.5.2. Time of Year
- 4.2.2. Mediums
 - 4.2.2.1. Optical
 - 4.2.2.1.1. Luminance
 - 4.2.2.1.2. Chromaticity
 - 4.2.2.1.3. Texture
 - 4.2.2.2. Non-visual Electromagnetics
 - 4.2.2.2.1. IR
 - 4.2.2.2.2. Radiation
 - 4.2.2.2.3. RF Propagation
 - 4.2.2.2.4. Background Noise
 - 4.2.2.3. Acoustic
 - 4.2.2.3.1. Ambient Noise
 - 4.2.2.3.2. Seismic
 - 4.2.2.4. Gravity
 - 4.2.2.5. Earth Magnetic Field

4.3. Host

- 4.3.1. Non-traditional Controls and Displays
- 4.3.2. Embedded Features
- 4.4.3. User
- 4.3.4. Data Logging
- 4.3.5. Computational Loading
- 4.3.6. Image Generation and Display
- 4.3.7. VV&A Activities
- 4.3.8. Simulation Class

4.4. Site

- 4.4.1. Physical Connections
- 4.4.2. Clocks
- 4.4.3. Data Logging
- 4.4.4. Security

- 4.4.5. Data Exchange
- 4.4.6. Contents (Supported hosts)
- 4.4.7. Network
 - 4.4.7.1. Transfer Protocols
 - 4.4.7.2. Delays
- 4.4.8. VV&A Past Activities
- 4.4.9. DIS Past Activities
- 4.4.10. DIS VV&A Past Activities
- 4.5. Application

- 4.5.1. Simulation Management
- 4.5.2. Scenario
 - 4.5.2.1. Doctrine
 - 4.5.2.2. Geopolitics
- 4.5.3. Network
 - 4.5.3.1. DIS Version
 - 4.5.3.2. PDUs Supported
- 4.5.4. Past VV&A Activities
- 4.5.5. Past DIS Activities
- 4.5.6. Past DIS VV&A Activities
- 4.5.7. Non-representational C3I
- 4.5.8. Non-representational Threats

5. Processes - The standard identifies two processes: *characterization* and *selection*. The characterization process is used to populate the database. It provides descriptions of simulators, simulations, and models. These descriptions are then used in the selection process to identify the particular systems to be employed in a DIS application. These processes should be defined by the companies or agencies involved. Paragraphs 5.1 and 5.2 describe a representative selection and characterization process.

5.1. Verification, Validation, and Accreditation VV&A is often integral to both the characterization and selection processes. For DOD applications VV&A appropriate to a specific service/component will be conducted for the simulator, simulation or model that falls under its purview. During the selection process VV&A will determine the compatibility of simulators, simulations, and models to be used in an application and then determine if application architecture, hardware, data and personnel can satisfy application objectives.

5.2. Sample Processes

5.2.1. Sample Characterization Process - The following process assumes that a military agency procures an aircraft training simulator that can be used in DIS applications, as well as in standalone operation. In DIS applications, this simulator will provide ownship state, ownship emissions, and four mobile surface-to-air missile sites to the network. The process is illustrated in figure 2, and has the following steps.

a. Define requirements - The military agency procuring the simulator identifies the requirements for DIS compatibility. This means that the simulator must:

1. Recognize a specific (or current) version of DIS protocol data units (PDU).
2. Respond to a subset of these protocols, and maintain normal operation should it receive protocols outside that set.

3. Produce and send its ownship entity state PDU and entity state PDUs for other entities represented in the simulator.

4. Produce and send other appropriate PDUs.

5. Pass a series of tests to verify the above requirements are satisfied.

In addition, the procuring agency requires that the contractor characterize the simulator. This requires that the contractor provide data for the database in the form required by Section 4 of the standard. Some of the data will be qualitative statements derivable from basic simulator attributes. Other data will consist of quantitative elements measured in accordance with the standard.

b. **Select Source and Develop the Simulator** - There are no differences from the agency's normal practices -- except to ensure that the additional DIS requirements are properly implemented. Appropriate Verification, Validation and Accreditation activities are performed.

c. **Test The Simulator** - There are two major differences in the test process. First, step 5 of paragraph a above must be performed. This will involve connecting this simulator to a network and verifying that appropriate data transmittal occurs. The second additional step involves actually measuring the fidelity characteristics required by the standard and recording the results. At the conclusion of the test, all appropriate data records in the repository should be populated. This test will normally be performed by the developing contractor and witnessed by the procuring agency. Appropriate Verification, Validation and Accreditation activities are performed.

d. **Deliver to Owner** - The procuring agency certifies that the characterization data are accurate, and turns the simulator data over to the simulation Owner.

e. **Deliver Characterization Data** - The simulator Owner identifies a point of contact and delivers the characterization data for incorporation into the repository. These include Verification, Validation and Accreditation when required

f. **Update for Changes** - As the simulator is changed, appropriate VV&A should be performed and the database should be updated as necessary.

5.2.2. **Sample Selection Process** - The following process illustrated in figure 3 assumes that a military agency does a large scale training exercise using DIS.

5.2.2.1. **Identify all Personnel to be Trained** - All personnel to be trained should be identified. It is especially important for a clear distinction to be made between the trainees and personnel involved in providing the training. If we are training the commander of a large scale operation it may be possible use very low fidelity aircraft simulations but the modeling of his command post may need to be highly realistic. In case the aircraft pilots of the aircraft are not being trained but are really part of a group of personnel providing the training. It will not usually be possible to provide total realism for all players. The exercise sponsor will provide this identification.

5.2.2.2. **Identify the Specific Training Objectives** - The specific training objectives will bound the problem of selecting the specific simulations for a DIS application in much the same manner as identifying the personnel to be trained. For example, we are training the pilots in air to air combat the ability of a simulator to drop bombs may not be relevant. Again the exercise sponsor should provide these objectives.

5.2.2.3. **Break the Objectives into Discrete Training Tasks** - Using the first two steps may not sufficiently define the problem to the extent necessary to easily select the potential simulations. This step breaks the problem down further. On the basis of the personnel to be trained, and the training objectives identify the skills, knowledge, and attitudes that must be imparted by the training exercise to the trainees as a result of the exercise and each participant's skills, knowledge, and attitudes. The differences are the specific training tasks that must be accomplished. This type of analysis should be provided by experts on the Sponsors staff.

5.2.2.4. **Relate the Discrete Tasks to Existing DIS Simulations** The sponsors staff in conjunction with the *DIS Support Organization* will use the *fidelity characteristics* to develop a list of candidate simulations that perform the required training. When required, the VV&A process will determine the compatibility of the simulations selected.

5.2.2.5. **Coordinate Simulation Availability** - The sponsors staff will then contact the Point of contact identified in the *fidelity characteristics database* to determine the availability and cost of using that particular simulation.

5.2.2.6. **Iterate as Necessary** - The desired simulations may not be available or may be too costly. A second choice may be available. If no second choice is available it may be necessary to change the tasks to be trained, the objectives, or even the personnel to be trained. When required, major VV&A activities will be conducted at this point.

5.3 **Formal VV&A Process** This process assumes an organization exists which manages DIS exercises. The following steps, as described below, are required for integrated VV&A of a distributed simulation (See figure 4).

1) An individual M&S is forwarded for integrated verification (compliance testing) following Service/DoD Component review. This review serves as a gateway allowing the Service/DoD Component to control those models put forth as candidates for compatibility with a distributed simulation environment. Included in the review process should be information describing the Service level VV&A conducted for the individual M&S. Information pertaining to the VV&A process and its results should be forwarded with the M&S to the distributed simulation control (DSC).

Similar structures may be used for non-Defense distributed simulations, but only Defense distributed simulations are addressed by these VV&A processes.

2) Integrated verification (compliance testing) of the individual M&S used in a particular distributed simulation environment (e.g., DIS, ALSP). M&S which are compliant with the protocols and standards are entered into a repository of M&S qualified for use in that distributed simulation environment. This repository, maintained by the DSC, contains information on qualified M&S, including M&S past VV&A history.

Integrated verification need only be conducted for an M&S when it is initially certified to be used in a particular distributed simulation environment or when a modification to or a new version of the M&S is released. Only those versions of the M&S which have undergone which have undergone integrated verification should be used in a distributed simulation exercise.

3) The user defines the requirements for the distributed simulation exercise. For this discussion, the user may be: the organization conducting the distributed simulation exercise, the organization for

which the distributed simulation exercise is being conducted, the organization using the results of the distributed simulation exercise, or some combination thereof.

4)An integrated conceptual model is defined by the user for the distributed simulation exercise based upon the requirements specified exercise. This integrated conceptual model identifies which M&S components will participate in the distributed simulation exercise, the architecture structure that connects the M&S, and any associated assumptions. The M&S repository provides the user information on those M&S eligible to participate in the distributed simulation exercise. The user can query the repository for information on suitable M&S and/or request advice from the DSC.

5)An integrated conceptual validation review is performed to ensure that all of the M&S selected for the distributed simulation exercise are compatible in light of the intended purposes of the exercise. Documented results of the conceptual validation of the distributed simulation exercise are sent to the repository via the DSC.

6)An integrated results validation review is performed to ensure that all of the M&S selected for the distributed simulation exercise and the architecture that combines them are acceptable for the intended purposes of the exercise. Documented results of the integrated results validation of the distributed simulation exercise are sent to the repository via the DSC.

7)An integrated accreditation review is performed to determine whether or not the M&S, architecture, hardware, data, and personnel along with all associated interactions of the distributed simulation will satisfy exercise requirements. Documented results of the integrated repository via the DSC.

8)Reports describing exercise results, problems incurred, etc. are forwarded to the repository via the DSC.

John E. Simone's figure (figure 4) must be attached. I believe you have it. Section 5.3 fits poorly with 5.2 Both have some essential points we should discuss at the September meeting. I do not believe all DIS exercises will go through a formal VV&A process. There are some terminology differences between VV&A and the rest of DIS.

See ATTACHED FIGURE

"DIST. SIM. VV&A PROCESS"

JPE

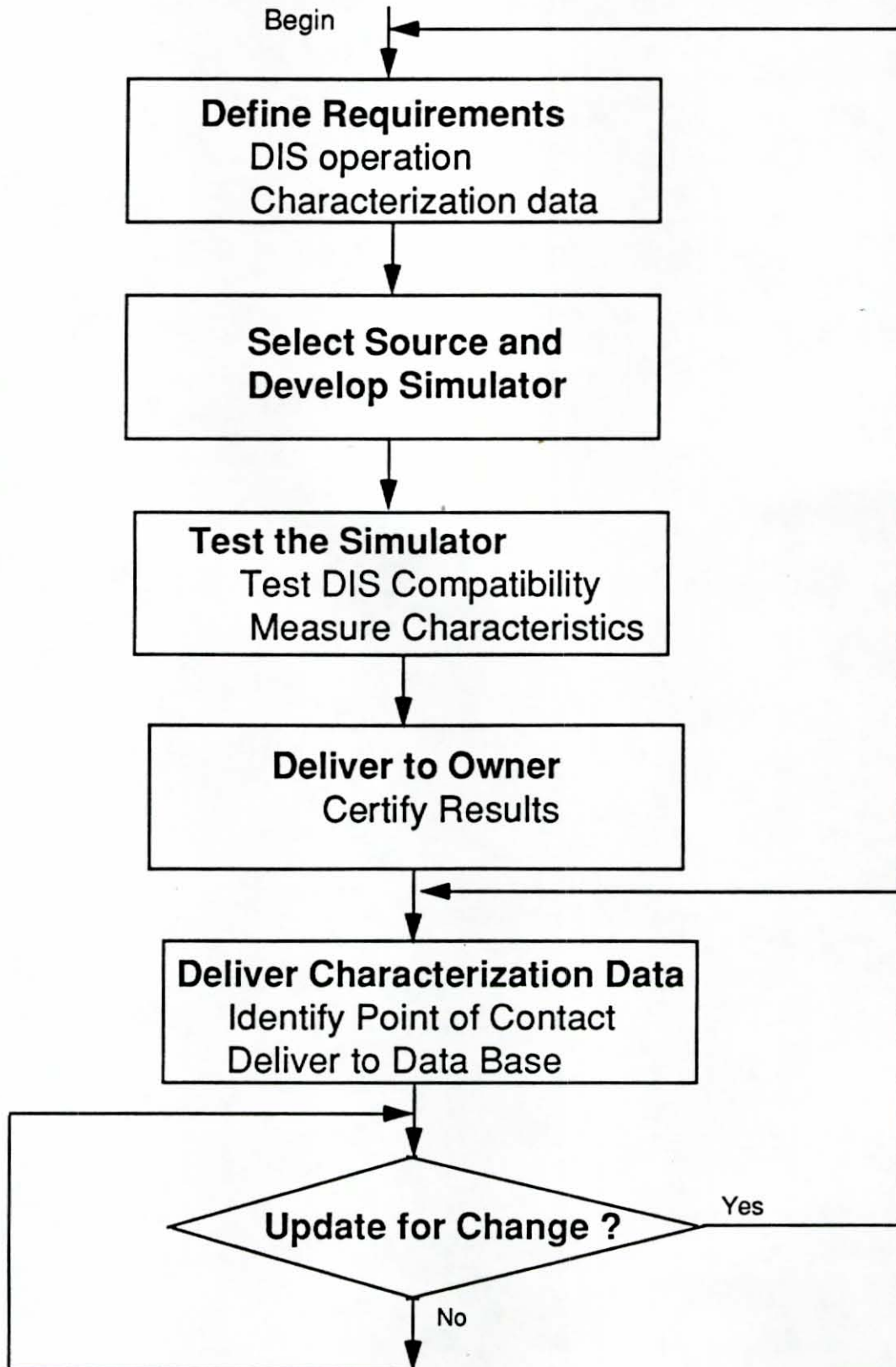


Figure 2 Characterization Example
Rationale for Fidelity Description Standard, page 9

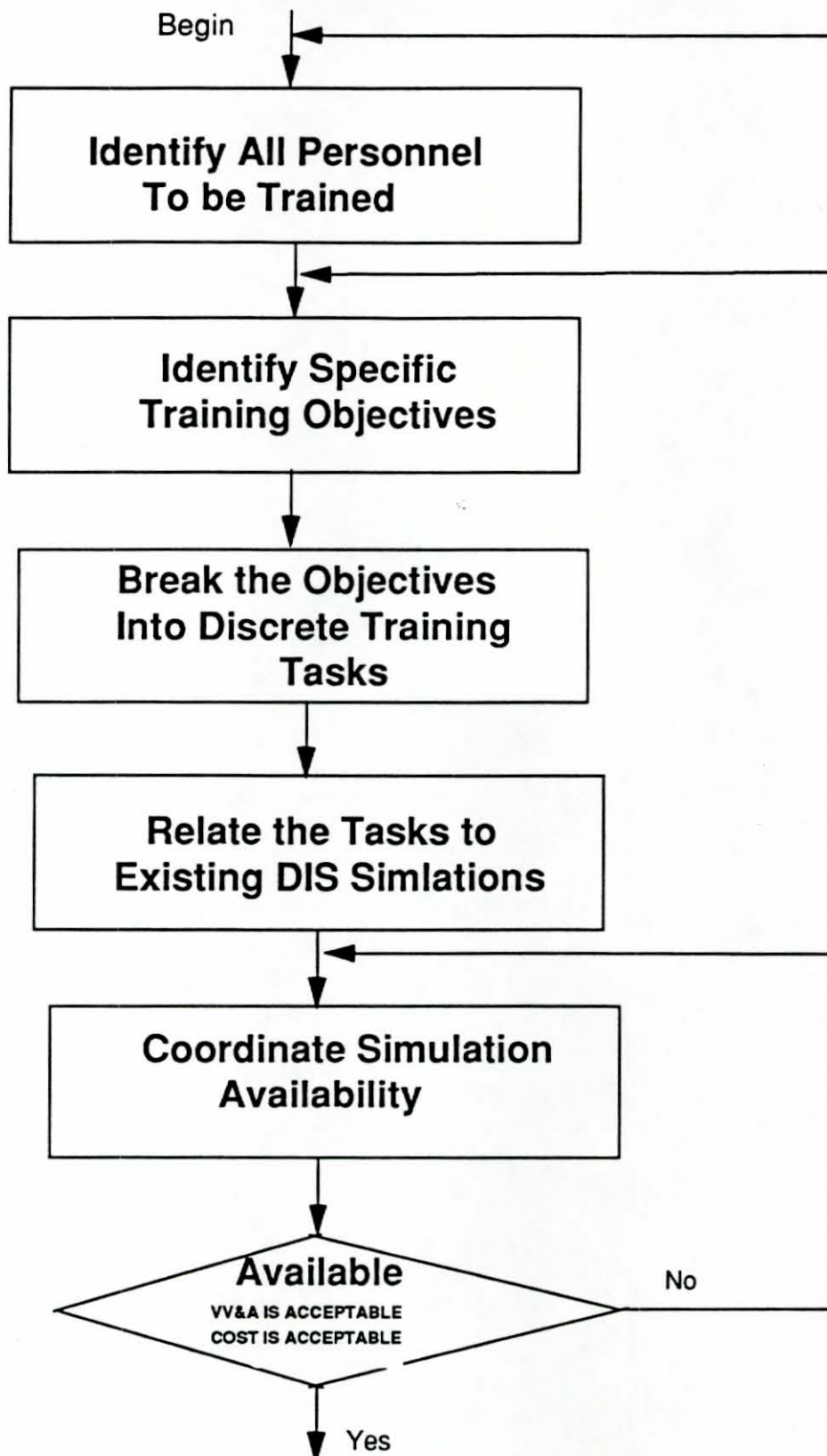
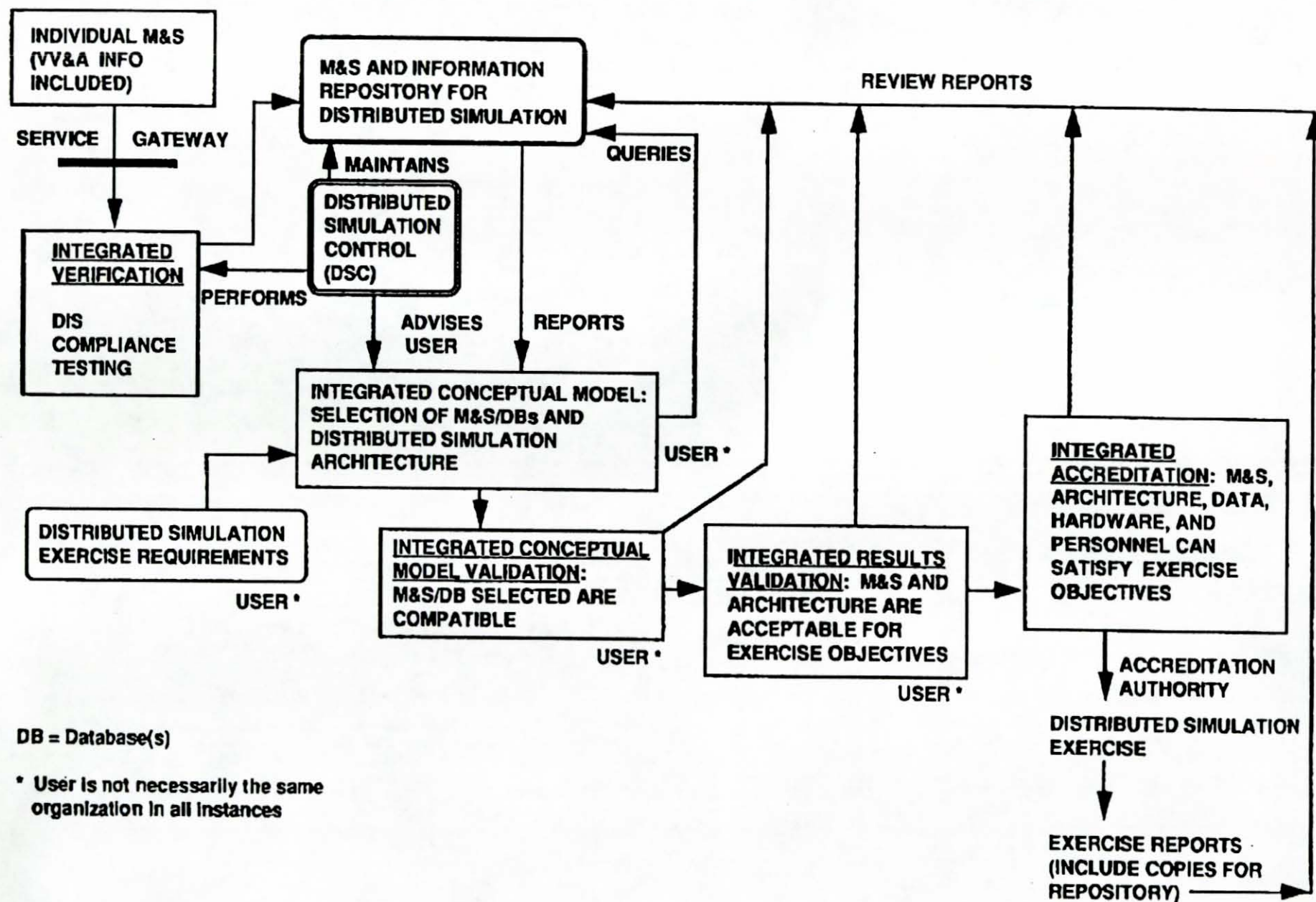


Figure 3 Selection Example

DISTRIBUTED SIMULATION VV&A PROCESSES



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